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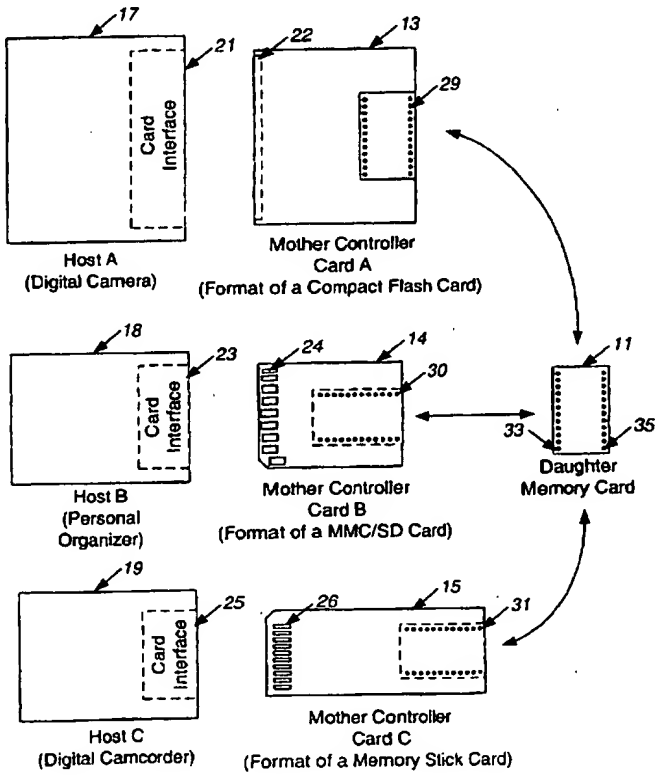
(54) Title: UNIVERSAL NON-VOLATILE MEMORY CARD USED WITH VARIOUS DIFFERENT STANDARD CARDS CONTAINING A MEMORY CONTROLLER



(57) Abstract: A mother/daughter card non-volatile memory system includes a daughter card containing the memory and a mother card containing the memory controller and host interface circuits. The daughter memory card contains as little more than the memory cell array as is practical, in order to minimize its cost, and has an interface for connecting with a variety of mother controller cards having physical attributes and host interfaces according to a number of different published or proprietary memory card standards. Different types of memory cards may be used when the operating parameters of the memory are stored within it in a protected location, the mother card controller then reading these parameters and adapting its operation accordingly. A radio frequency antenna may be included on a surface of the card along with its electrical contacts, in order to provide a radio frequency identification function.

WO 2004/044755 A2

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UNIVERSAL NON-VOLATILE MEMORY CARD USED WITH VARIOUS DIFFERENT STANDARD CARDS CONTAINING A MEMORY CONTROLLER

FIELD OF THE INVENTION

[0001] This invention relates generally to the use and structure of removable electronic circuit cards having different mechanical and/or electrical interfaces, particularly those including mass non-volatile integrated circuit memory.

BACKGROUND OF THE INVENTION

[0002] Electronic circuit cards, including non-volatile memory cards, have been commercially implemented according to a number of well-known standards. Memory cards are used with personal computers, cellular telephones, personal digital assistants, digital cameras, portable audio players and other host electronic devices for the storage of large amounts of data. Such cards usually contain a non-volatile semiconductor memory cell array along with a controller that controls operation of the memory cell array and interfaces with a host to which the card connected. Several of the same type of card may be interchanged in a host card slot designed to accept that type of card. However, the development of the many electronic card standards has created different types of cards that are incompatible with each other in various degrees. A card made according to one standard is usually not useable with a host designed to operate with a card of another standard.

[0003] One such standard, the PC Card Standard, provides specifications for three types of PC Cards. Originally released in 1990, the PC Card Standard now contemplates three forms of a rectangular card measuring 85.6 mm. by 54.0 mm., having thicknesses of 3.3 mm. (Type I), 5.0 mm. (Type II) and 10.5 mm. (Type III). An electrical connector, which engages pins of a slot in which the card is removably inserted, is provided along a narrow edge of the card. PC Card slots are included in current notebook personal computers, as well as in other host equipment, particularly portable devices. The PC Card Standard is a product of the Personal Computer Memory Card International Association (PCMCIA). The latest release of the PC

Card Standard from the PCMCIA is dated February 1995, which standard is incorporated herein by this reference.

[0004] In 1994, SanDisk Corporation introduced the CompactFlash™ card (CF™ card) that is functionally compatible with the PC Card but is much smaller. The CF™ card is rectangularly shaped with dimensions of 43 mm. by 36 mm. and a thickness of 3.3 mm., and has a female pin connector along one edge. The CF™ card is widely used with cameras for the storage of video data. A passive adapter card is available, in which the CF™ card fits, that then can be inserted into a PC Card slot of a host computer or other device. The controller within the CF™ card operates with the card's flash memory to provide an ATA interface at its connector. That is, a host with which a CF™ card is connected interfaces with the card as if it is a disk drive. Specifications for the card have been developed by the CompactFlash Association, a current version of these specifications being 1.4, which standard is incorporated herein by this reference.

[0005] The SmartMedia™ card is about one-third the size of a PC Card, having dimensions of 45.0 mm. by 37.0 mm. and is very thin at only 0.76 mm. thick. Contacts are provided in a defined pattern as areas on a surface of the card. Its specifications have been defined by the Solid State Floppy Disk Card (SSFDC) Forum, which began in 1996. It contains flash memory, particularly of the NAND type. The SmartMedia™ card is intended for use with portable electronic devices, particularly cameras and audio devices, for storing large amounts of data. A memory controller is included either in the host device or in an adapter card in another format such as one according to the PC Card standard. Physical and electrical specifications for the SmartMedia™ card have been issued by the SSFDC Forum, a current version of this standard being 1.0, which standard is incorporated herein by this reference.

[0006] Another non-volatile memory card is the MultiMediaCard (MMC™). The physical and electrical specifications for the MMC™ are given in "The MultiMediaCard System Specification" that is updated and published from time-to-time by the MultiMediaCard Association (MMCA). Version 3.1 of that Specification, dated June 2001, is expressly incorporated herein by this reference. MMC™ products having varying storage capacity up to 128 megabytes in a single card are currently available from SanDisk Corporation. The MMC™ card is rectangularly shaped with

a size similar to that of a postage stamp. The card's dimensions are 32.0 mm. by 24.0 mm. and 1.4 mm. thick, with a row of electrical contacts on a surface of the card along a narrow edge that also contains a cut-off corner. These products are described in a "MultiMediaCard Product Manual," Revision 2, dated April 2000, published by SanDisk Corporation, which Manual is expressly incorporated herein by this reference. Certain aspects of the electrical operation of the MMC™ products are also described in United States patent no. 6,279,114 and in patent application Serial No. 09/186,064, filed November 4, 1998, both by applicants Thomas N. Toombs and Micky Holtzman, and assigned to SanDisk Corporation. The physical card structure and a method of manufacturing it are described in U.S. patent no. 6,040,622, assigned to SanDisk Corporation. Both of these patents and patent application are expressly incorporated herein by this reference.

[0007] A modified version of the MMC™ card is the later Secure Digital (SD) card. The SD Card has the same rectangular size as the MMC™ card but with an increased thickness (2.1 mm.) in order to accommodate an additional memory chip when that is desired. A primary difference between these two cards is the inclusion in the SD card of security features for its use to store proprietary data such as that of music. Another difference between them is that the SD Card includes additional data contacts in order to enable faster data transfer between the card and a host. The other contacts of the SD Card are the same as those of the MMC™ card in order that sockets designed to accept the SD Card can also be made to accept the MMC™ card. This is described in patent application Serial No. 09/641,023, filed by Cedar et al. on August 17, 2000, which application is incorporated herein by this reference. The electrical interface with the SD card is further made to be, for the most part, backward compatible with the MMC™ card, in order that few changes to the operation of the host need be made in order to accommodate both types of cards. Specifications for the SD card are available to member companies from the SD Association (SDA).

[0008] Another type of memory card is the Subscriber Identity Module (SIM), the specifications of which are published by the European Telecommunications Standards Institute (ETSI). A portion of these specifications appear as GSM 11.11, a recent version being technical specification ETSI TS 100 977 V8.3.0 (2000-08), entitled "Digital Cellular Telecommunications System (Phase 2+); Specification of the

Subscriber Identity Module – Mobile Equipment (SIM – ME) Interface," (GSM 11.11 Version 8.3.0 Release 1999). This specification is hereby incorporated herein by this reference. Two types of SIM cards are specified: ID-1 SIM and Plug-in SIM.

[0009] The ID-1 SIM card has a format and layout according to the ISO/IEC 7810 and 7816 standards of the International Organization for Standardizaton (ISO) and the International Electrotechnical Commission (IEC). The ISO/IEC 7810 standard is entitled "Identification cards – Physical characteristics," second edition, August 1995. The ISO/IEC 7816 standard has the general title of "Identification cards – Integrated Circuit(s) Cards with Contacts," and consists of parts 1-10 that carry individual dates from 1994 through 2000. These standards, copies of which are available from the ISO/IEC in Geneva, Switzerland, are expressly incorporated herein by this reference. The ID-1 SIM card is generally the size of a credit card, having dimensions of 85.60 mm. by 53.98 mm., with rounder corners, and a thickness of 0.76 mm. Such a card may have only memory or may also include a microprocessor, the latter often being referred to as a "Smart Card." One application of a Smart Card is as a debit card where an initial credit balance is decreased every time it is used to purchase a product or a service.

[0010] The Plug-in SIM is a very small card, smaller than the MMC™ and SD cards. The GSM 11.11 specification referenced above calls for this card to be a rectangle 25 mm. by 15 mm., with one corner cut off for orientation, and with the same thickness as the ID-1 SIM card. A primary use of the Plug-in SIM card is in mobile telephones and other devices for security against the theft and/or unauthorized use of the devices, in which case the card stores a security code personal to the device's owner or user. In both types of SIM cards, eight electrical contacts (but with as few as five being used) are specified in the ISO/IEC 7816 standard to be arranged on a surface of the card for contact by a host receptacle.

[0011] Sony Corporation developed a non-volatile memory card, sold as the Memory Stick™, that has yet another set of specifications. Its shape is that of an elongated rectangle having electrical contacts on a surface adjacent one of its short sides. The electrical interface through these contacts with a host to which it is connected is unique.

[0012] As is apparent from the foregoing summary of the primary electronic card standards, there are many differences in their physical characteristics including size and shape, in the number, arrangement and structure of electrical contacts and in the electrical interface with a host system through those contacts when the card is inserted into the host card slot. Electronic devices that use electronic cards are usually made to work with only one type of card. Adaptors, both active and passive types, have been provided or proposed to allow some degree of interchangeability of electronic cards among such host devices. U.S. patent no. 6,266,724 of Harari et al. describes use of combinations of mother and daughter memory cards, which patent is incorporated herein in its entirety by this reference.

SUMMARY OF THE INVENTION

[0013] According to a primary aspect of the present invention, a very small (less than the size of a postage stamp) sub-card or daughter card containing non-volatile memory is removably connectable with one or more electronic cards or mother cards made according to different specifications, such as those of two or more of the above-described incompatible standards, while memory control and unique host interface functions remain on the mother cards. The mother cards individually interface, both mechanically and electrically, with host devices in the same manner as previously. But the non-volatile memory of each type of mother card has been removed and a standard memory interface substituted on the mother card. A universal memory daughter card is removably connectable with any of several different types of mother cards through the standard memory card interface. An advantage of the universal memory card is its reduced size and cost since the memory controller and host interface electronics reside on the mother cards. Since primarily only the memory storage cells are included on the memory card, its cost can be significantly lower than the memory cards described above that each also contain the memory controller and host interface. This standard memory interface between mother card and daughter card is to be distinguished from the host interface between the mother card and the host. While various adaptors may now be used to allow otherwise incompatible memory cards to communicate with a variety hosts, the subject of this aspect of the

present invention is the mother/daughter card interface using a standardized universal interface.

[0014] According to another aspect of the present invention, such daughter memory cards may be removably carried by a larger substrate (such as one the size of a credit card) for distributing, handling and/or storing, and accessing the very small memory daughter cards. Because of their relatively low cost, the memory cards can be used for permanent storage of data. Video data, such as photographs, and audio data, such as music, are examples of the use of such memory cards by individuals. A storage card preferably carries one or more such memory cards and includes a surface area for the user to write by hand or otherwise uniquely identify or maintain a record of the data content of the memory card(s) attached to it. The memory cards may be distributed and sold through retail channels by selling the storage cards with one or more memory cards attached to each. The storage card may optionally include electrical contacts to which contacts of the attached memory card are connected through the storage card for the purpose of reading the data stored on the memory card, such as by inserting the storage card into a reader connected with a personal computer in the home or office, without having to remove the memory card from the storage card. Alternatively, the storage card may be sized according to the standards for a popular one of the cards described above, such as the Smart Card (ID-1 SIM), with the memory card having a pattern of contacts and position on the storage card according to that same standard, thereby allowing the storage card with an attached memory card to be inserted into existing or suitably adapted card readers and read through the memory card contacts. Further contacts need not be provided on the storage card in order to access the memory card.

[0015] Additionally, the storage card for daughter memory cards may be provided with an intelligent controller capable of communicating with existing memory card readers using a variety of existing formats as outlined above for the mother cards. This controller may even communicate using the popular USB protocol in which case the storage card becomes functionally equivalent to the combination of a mother card and a reader and may plug into a passive adaptor meeting the mechanical standards for a USB connector.

[0016] In yet another variation, the identity of the daughter card(s) contained on the storage card may be read out using a contactless RF Identification mode. Suitable RF circuitry may be included either on the daughter card itself or on the storage card. In either case the power required to read out data contained in a predefined portion of the daughter card is provided by the incoming RF signal. The card then responds by modulating the incoming RF signal in such a way that the external RF receiver can interpret the code and thus uniquely identify the daughter card.

[0017] According to a further embodiment of the present invention, the daughter memory card is made in accordance with one of the existing card standards but with additional contacts added for connecting with the standard memory interface of the mother cards. This then allows the memory card to have a dual function: it can be used in the same manner as an existing card, directly with the host, or as a daughter card with one of the mother cards. As an illustration, contacts are added to the small Plug-in SIM card described above on the card's surface to surround the existing eight contacts that are provided as part of the ISO/IEC 7816 standard. The card may then be used in a host device in the same manner as the Plug-in SIM card, or as a memory daughter card when coupled with a mother card according to another one of the standards. For example, the contacts required for communication using ISO/IEC 7816 protocol may be used during powerup initialization to identify the card and allow authentication for access by the host or mother card to the data content of the card. This communication may then use the additional memory interface contacts at much higher speeds using the standardized communication protocol.

[0018] A patent application of Wallace et al., entitled "Use of Small Electronic Circuit Cards with Different Interfaces in an Electronic System" describes a combination of memories according to two different standards in a single memory card that shares a single set of card contacts. This application, Serial No. 09/633,089, filed August 4, 2000, is hereby incorporated herein by this reference.

[0019] According to yet another aspect of the present invention, provision is made for accommodating future changes to the daughter card memory when such changes may affect the manner in which the mother card controller or a host controller needs to operate. A dedicated portion of the daughter card memory space accessible to the mother card controller (but preferably not to the user) contains data of specific

operating parameters of the memory. Once the daughter card is detected, the mother card controller reads these parameters upon initialization, or whenever a new daughter memory card is inserted into the mother card receptacle, and then configures itself to operate the card and its memory accordingly. The memory system operating parameters that may be set in this way include algorithms for writing data into the memory, reading data from the memory, erasing blocks of the memory, correcting errors in read data, and the creation of a file system. Other parameters include levels of voltages required by the daughter memory card, the size of memory cell blocks that are the minimum number of cells erased together, the size of pages of memory cells within the blocks that are programmed together and other aspects of large memory cell block management. The parameters chosen to be stored for controlling operation of the memory are those expected to change in the future as the memory technology evolves. Other parameters may include information about the security features for content protection, the unique daughter card identification number, information on how the mother card should handle multi-bit per cell storage on the daughter card, as well as whether the daughter card is operable as a "one time write", multiple write, read only, or non-memory functions such as applications for optimized operation of the daughter card in specific hosts. The mother card controller, and in some cases the host system to which the mother and daughter cards are connected, then adapt to the parameters stored in a connected daughter memory card.

[0020] Additional features, aspects and advantages of the present invention are included in the following description of exemplary embodiments, which description should be taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Figure 1 schematically illustrates specific examples of the use of a common daughter memory card with three different mother controller cards having incompatible specifications;

Figure 2 is an electronic block diagram that shows the functions contained in a host device, a mother controller card and a daughter memory card;

Figure 3 illustrates a storage card to which daughter memory cards are removably attached, and a reader having a slot in which the storage card may be inserted in order to read data from the memory cards attached to it;

Figure 4 schematically illustrates an application of the daughter memory card, the storage card and the mother controller card for taking and storing data of photographs taken by a camera;

Figure 5 schematically illustrates an application of the daughter memory card and the storage card, without use of the mother controller card, for taking and storing data of photographs taken by a camera;

Figure 6A is a plan view of a specific example of a daughter memory card;

Figure 6B is a cross-sectional view of the memory card of Figure 6A, taken at section B-B thereof;

Figure 7 shows one example of a receptacle within a mother controller card or a host device for receiving the memory card of Figures 6A and 6B;

Figure 8 shows example mounting details of a surface mounted daughter card of the type shown in Figures 6A and 6B;

Figure 9 is a plan view of another example daughter memory card with surface contacts arranged differently than in the example of Figure 6A;

Figure 10 is a plan view of a lead frame that can be in the manufacturer of the card of Figure 9;

Figure 11A is a plan view of a first specific example of the card shown in Figure 9 that uses the lead frame of Figure 10;

Figure 11B is an end view of the memory card of Figure 11A;

Figure 11C is a side view of the memory card of Figure 11B;

Figure 12A is a plan view of a second specific example of the card shown in Figure 9 that uses the lead frame of Figure 10;

Figure 12B is an end view of the memory card of Figure 12A;

Figure 12C is a side view of the memory card of Figure 12B;

Figure 13 is another example of a storage card with removably attached memory cards according to Figures 6A or 9, that is different than the storage card of Figure 3; and

Figure 14 is a plan view of yet another memory card example.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0022] Figure 1 illustrates a common use of a daughter memory card 11 with three different mother cards 13, 14 and 15. The mother card 13 is designed to work with a host device 17 but not with host devices 18 or 19. As an example, the mother card 13 may have the same physical shape and host electronic interface as a CompactFlash™ card and the host 17 may be a digital camera. Similarly, the mother card 14 is designed to work with the host device 18 but not with host devices 17 or 19, and the mother card 15 is designed to work with the host device 19 but not with host devices 17 or 18. Also as examples, the mother card 14 may have the same physical shape and host electronic interface as either of the MMC™ or SD cards, and the host 18 may be a personal organizer. Further, the mother card 15 may have the same physical shape and host electronic interface as the Memory Stick™ card, and the host 19 may be a digital camcorder or any of a multitude of products currently offered for sale by Sony Corporation. A card slot 21 of the host 17 is physically shaped to accept insertion and removal of the mother card 13. A connector 22 of the mother card 13 mates with a matching connector within the card slot 21. Similarly, a card slot 23 of the host 18 accepts the mother card 14, and a card slot 25 of the host 19 accepts the mother card 15. A row of surface contacts 24 on the mother card 14 is contacted by a matching set of conductive elements of host card slot 23 (not shown) and a row of surface contacts 27 on the mother card 15 is contacted by a matching set of conductive elements of the host card slot 25.

[0023] The daughter memory card 11 is removeably received on each of the mother cards 13, 14 and 15 by some convenient electrical/mechanical arrangement thereon, shown to be in example positions 29, 30, and 31, respectively. Two rows of contacts 33 and 35 are shown on a surface of the memory card 11, as an example, for mating with a similarly arranged set of contacts within the mother cards 13, 14 and 15 when the memory card 11 is positioned thereon. Other contacting arrangements on the daughter card, such as a set of connecting surfaces on either or both flat surfaces, or contacts along one or more sides or edges, may be used. In the illustrated embodiment, each of the mother card 13, 14 and 15 substantially encloses the daughter card 11 but this is not required. A variety of methods to mate the cards may be used such as a slot, guide rail, or click-in-place mechanism. The daughter card may also include an indentation in a variety of shapes allowing removal with a narrow

object such as a pencil point or nail, and it may also include a retention detent to ensure reliable contact. Alternatively, one or all of the mother cards 13, 14 and 15 may have provisions for retaining the memory card on its outside surface, such as by having a recessed surface region in the same shape as the memory card. In either of these examples, electrical contact is made with the memory card contacts 33 and 35 by appropriate electrical connectors within either the slot, recess or other physical memory card receptacle of each mother card. Many identical memory cards 11 will generally be used, one at a time, with any given mother card. Blank memory cards can be used in this way to store data from a host into which the mother card is inserted, or memory cards with data stored on them may be attached to a mother card for reading its data by a host into which the mother card is operably connected.

[0024] The mother card 13, in this example, has all the physical attributes and electrical host interface of a CompactFlash™ card, as well as a memory controller, but does not contain the mass non-volatile memory storage that is currently included in such a card. Rather, that mass memory is included in the daughter memory card 11 that is connectable with the mother card 13. Further, in this example, the mother card 14 corresponds to a MMC™/SD card with its mass memory removed and the receptacle 30 provided to receive the memory card 11 instead. Similarly, in this example, the mother card 15 corresponds to a Memory Stick™ card but with its mass memory removed and the receptacle 31 provided to receive the memory card 11 instead. Alternatively, other types of memory cards having the physical and electrical interface characteristics according to card standards other than CompactFlash™, MMC™/SD, and Memory Stick™, including those described above in the Background and others, may similarly be modified to remove their mass memory into the separate memory card 11.

[0025] The memory card 11 may have a capacity of 8, 16, 32, 64, 128 or more megabytes of non-volatile memory, for example of the flash EEPROM type, or of a one-time programmable memory that can be used for archival storage purposes. Indeed, memory cards of various capacities are expected to be sold to end users, so that only the amount of memory desired for a particular application need be purchased. The memory card is preferably plastic encased with electrical contacts of some convenient pattern across one or both surfaces of the card. The memory card 11